Volume 18 June, 1932 *Number 6*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

High Temperature Bearing Service Lubrication Requirements

Worm Reduction Gear Lubrication

PUBLISHED BY

THE TEXAS COMPANY

TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICANTS
FOR BEARINGS SUBJECTED TO STEAM HEAT

IN THE PAPER MILL

GRINDERS

Pocket Grinders Hand Operated	*A**	TEXACO CRANK CASE OIL TEXACO PELICAN OIL OR TEXACO SUMMER BLACK OIL
	*B**	TEXACO 629 CYLINDER OIL TEXACO PELICAN OIL OR TEXACO SUMMER BLACK OIL
Pocket Grinders Continuous	*Main Bearings*	TEXACO ALGOL OR URSA OIL OR TEXACO ALTAIR OIL
Warren Voight and Warren Continuous Grinders	*Enclosed Reduction Gears*	TEXACO 650 T MINERAL CYLINDER OIL TEXACO 629 CYLINDER OR TEXACO PINNACLE MINERAL CYL. OIL
	Open Reduction Gears	TEXACO AXLE GREASE GRAPHITE
	Reduction Gear Shaft Bearings Chain Pins and Rollers	TEXACO CUP GREASE NO. 00 OR NO. 1

PAPER MACHINE DRIER SECTION

Continuous Oiling Systems		TEXACO ALGOL OIL OR TEXACO URSA OIL
Intermittent Lubrication	*A**	TEXACO ALCAID OIL OR TEXACO ALGOL OIL TEXACO ALEPH OIL OR TEXACO ALTAIR OIL
	*B**	TEXACO ALGOL OIL TEXACO ALTAIR OIL OR TEXACO 629 CYLINDER OIL
Grease Lubrication		TEXACO HYTEX GREASE NO. 5 OR NO. 7 TEXACO WOOL YARN GREASE
Anti-Friction Bearings — Oil Lubricated		TEXACO URSA OIL
Grease Lubricated		TEXACO MARFAK GREASE NO. 2 OR TEXACO CUP GREASE NO. 00
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Drier Roll Gears — Open		TEXACO AXLE GREASE GRAPHITE
Enclosed		TEXACO URSA OIL
Calender Rolls — Anti-Friction Bearings		TEXACO URSA OIL
Plain Bearings		TEXACO URSA OIL, TEXACO ALGOL OR TEXACO ALTAIR OIL
Winder, Re-Winder Rolls and Back Drive Bearings — Oil Lubricated — Anti-Friction and Plain "A" Bearings		TEXACO ALCAID OIL OR TEXACO ALGOL OIL TEXACO ALEPH OIL OR TEXACO ALTAIR OIL
Plain "B" Bearings		TEXACO ALGOL OIL OR TEXACO ALTAIR OIL
Grease Lubricated — Anti-Friction		TEXACO MARFAK GREASE NO. 1 OR NO. 2
Plain Type Bearings		TEXACO WOOL YARN GREASE
Back Drive Magnetic Clutches		TEXACO MARFAK GREASE NO. 3
Back Drive Iron to Wood Gears		TEXACO AXLE GREASE GRAPHITE

FINISHING ROOM

Super Calenders		TEXACO ALGOL OIL TEXACO ALTAIR OIL OR TEXACO URSA OIL

*A**—Close fitting bearings, lubricated by ring or automatic oiling devices.
*B**—Bearings worn, loose or out of alignment; also hand oiled plain bearings.

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High Temperature Bearing Service Lubrication Requirements

UTILIZATION of steam heat for drying purposes in the textile industry, the manufacture of paper and the rubber trade, has led to considerable study of bearing design from the viewpoint of lubrication, for a condition of temperature will normally prevail which may impose severe duty upon the roll neck or journal bearings if these latter are not protected by suitable lubrication. Until recently the plain sleeve type bearing has been used to a great extent. Developments in the paper industry, however, have proved the adaptability of the anti-friction bearing to such service. The dryer end of the paper machine is noteworthy in this regard.

Lubrication of bearings subjected to steam heat becomes a problem due to the fact that the journals or roll necks of the heating elements are cored out for the purpose of admitting steam to the interior. The temperature of this latter will depend upon the rate of drying or amount of heat desired.

In the paper trade, steam as an adjunct to manufacture is first used in connection with the development of wood pulp in certain types of grinders preparatory to conversion into paper. Here the bearings are not only subjected to such heat as may be transmitted from the steam, but also severe loads are frequently involved, due to the weight of the grinding element, as well as the impact developed by its action upon the logs.

The operation of the paper machine in turn, requires a slow, even rate of heating, to avoid making a paper which may be brittle, and to develop a stock which is comparatively air dry. Here the paper web contains about sixty per-cent of water as it comes to the dryer end of the machine.

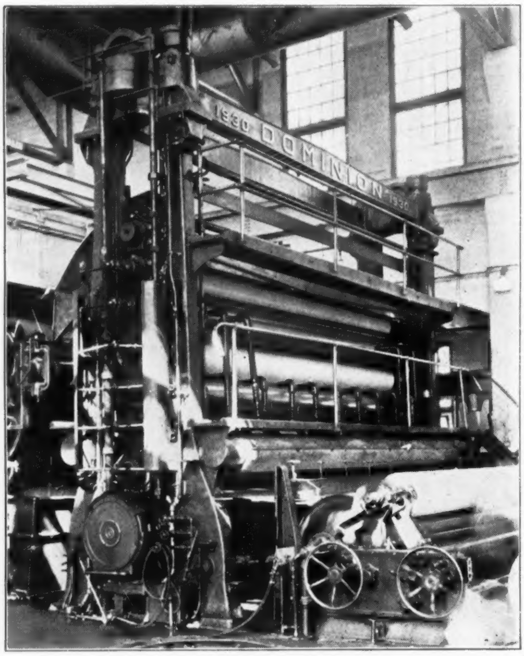
The rubber calender is another type of machine where an excess of temperature might be a detriment and yet, where the surface of the rolls must be maintained at a comparatively high degree to perform their function successfully. In the operation of the rubber mill there is also the problem of chilling to be considered, where cold water is run into the rolls after steam heating.

For heating purposes either live or exhaust steam can be used. Live steam of reduced pressure is advantageous in that it can normally be obtained in a dryer state than exhaust. Furthermore, unless a plant may be operating a considerable number of steam driven units, there may not be sufficient exhaust available.

Assuming that steam will vary from 10 to 100 pounds in pressure, reference to a steam table will show that temperatures of from 240 to 340 degrees Fahr., must be considered. This will not necessarily indicate the temperature range within the clearance spaces of the roll journal bearings. It will, however, indicate that the lubricant must function at a probable temperature considerably above normal room conditions.

DRYING PAPER STOCK

The process of drying paper involves a continuation of the rolling action already begun on the wet end. At the dry end, however, the roll mechanisms consist of a series of hollow



Courtesy of Dominion Engineering Works, Ltd.

Fig. 1—Showing the calender stack of a 226 inch newsprint machine. Piping arrangement for bearing lubrication can be seen at the end of the machine.

cast iron cylinders, heated internally by steam. On certain types of machines there may be from fifty to one hundred or more of such dryers. These elements are built to run in synchronism, being geared together in order to function in absolute unison with each other, thereby subjecting the sheet to virtually constant tension. The sheet is passed to the first set of dryers directly from the press or felt rolls on the wet end of the machine. The arrangement of the dryers has a good deal to do with the finished surface of the paper. A method of developing a glaze is to operate one large dryer of this nature in conjunction with a series of smaller pressure rolls, anticipating the function of the calender stack to a certain extent.

In order to enable the dryer end of a paper machine to function properly, effective steam joints are decidedly essential, for leakage must be prevented as far as possible, in the interest of heat conservation and reduction of the possibility of damage or staining. This latter may be developed if steam leakage occurs, due to the oil content of the steam, especially where exhaust steam may be passed to open type feed water heaters and subsequently returned to the boilers without adequate removal of any cylinder oil which it may contain. Obviously regeneration of live steam may cause a certain amount of this oil to be carried over the dryers, to reduce the efficiency of drying should the interior of the rolls become insulated with a film of oil.

In consequence all steam joints must be carefully checked, in order that leakage may be corrected as soon as possible, for steam joints present one of the greatest potential power consuming elements in the paper industry. They should never be screwed up too tightly, however, for this may cause wear. Steam joints can be adequately protected by cylinder oil or grease; the use of either, properly applied to the faces of the moving parts, will insure effective lubrication, prevention of wear and elimination of leakage.

Means of Lubrication

Dryer roll and calender bearing lubrication must be studied from the viewpoints of high temperature and pressure. Fortunately, speed is not much of a factor in dryer roll operations. On the other hand, inaccessibility must be given due consideration, for the bearings on the back or steam side of certain machines may be impossible to reach, due to the driving gears. As a result some means of automatic lubrication is decidedly essential. In some instances a combination of the wick feed oiler and waste pad will serve the purpose, where plain or sleeve type construction prevails, especially if the top bearing is built with a suitable recess or waste pad pocket. Under such conditions the wick oiler will automatically deliver the requisite amount of oil to the pad to maintain dependable lubrication. The principles of both capillary and syphonic action can be used by designing such systems so that the pad end of the wick is lower than the end immersed in the oil reservoir.

Ring or collar oilers have also been used to good advantage, in connection with plain bearings. On more recently designed machines, however, anti-friction bearings of both ball and roller type have been extensively used. The ring or collar design in conjunction with an automatic oil circulating system is particularly noteworthy, for circulation, if properly accomplished, will insure against over-heating, the flood of oil acting more or less as a cooling or heat removing medium. Furthermore, means of filtration and cooling can be readily installed with such systems to give the further advantage of clean, cool oil. There is also a decided element of dependability involved, for in case there should be any interruption of oil flow, due to breakdown of the circulating system, or should it have to be cut out temporarily for

minor repair or adjustment, the capacity of the bearing reservoirs and the automatic action of the rings or collars in maintaining oil circulation will insure dependable and continued lubrication over the average length of time required for the work involved.

Where it is not practicable to install an extensive circulating system, however, somewhat the same results will be attained by using a wick oiler in conjunction with each set of rings or collars, with a common manifold or oil reservoir.

Use of anti-friction bearings permits of application of either oil or grease lubrication according to the sealing arrangement of the bearings and the means provided for re-lubrication. Experience with such bearings on recent installations have proved their economy from a lubrication point of view and the practicability of maintaining continued operation, even in the presence of comparatively high temperatures, provided proper cooling by water circulation can be maintained and the lubricants are chosen with regard to their operating viscosity or consistency at the prevailing bearing temperatures.

Choice of Lubricants

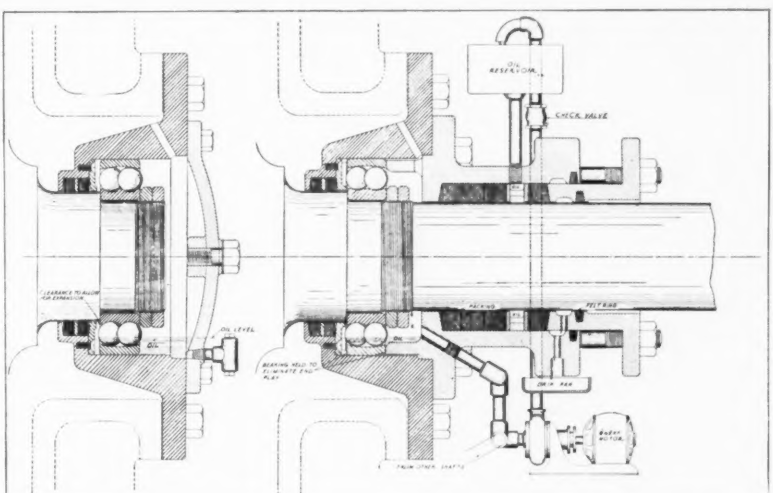
Among the detrimental results which may accrue from impaired lubrication may be sagging of cylinders, especially where the back end bearings are affected. If allowed to continue this may necessitate undue expense for repair, as well as loss of time during the period of shut-down. Such conditions can be prevented if due care is given to study of the several means of lubrication available, according to bearing construction, and the choice of a suitable lubricant.

To meet the pressure and temperature conditions, where oil is called for it should normally be of comparatively heavy body, ranging from 60 to 170 seconds Saybolt at 210 degrees Fahr., according to the condition of the bearings, the means of application and the temperatures. Ease of distribution is important and might be regarded as an argument in favor of lower viscosity. On the other hand, the more fluid the product the more readily it may pass off when exposed to comparatively high temperatures.

Where ball or roller bearings are employed choice of lubricant is extended to grease, application being normally made by pressure gun. In selection of greases for bearings subjected to higher temperatures the viscosity of the oil content as well as melting point of the product must be considered. In the modern paper mill equipped with anti-friction bearings extreme care has been given to bearing design, hence it is not essential to use as heavy a viscosity oil in compound as would be necessary on bearings where leakage might occur. Experience has indicated that 300 seconds Saybolt at 100 degrees Fahr., will suffice, provided sufficient high grade soap is used to bring the resultant grease to a light or semi-plastic consistency.

Back Drive Bearings

The paper machine back drive also requires careful consideration in such a discussion of lubrication. On older machines the bearings are of the plain sleeve type, designed for ring or chain oiling, or grease lubrication. To meet the average operating conditions which these will involve, an oil of approximately 500 seconds Saybolt viscosity at 100 degrees Fahr., is preferable. Under high speed operation, however, especially where unusually tight belts may be involved, a heavier oil or even a wool yarn grease may be necessary. For this reason, the tendency has been to adopt the anti-friction bearing in more up-to-date back drive construction. This has been proved extremely adaptable and has eliminated lubrication difficulties to a marked degree. Grease lubrication is frequently adaptable on such bearings, using a product similar to that required for dryer roll bearings.

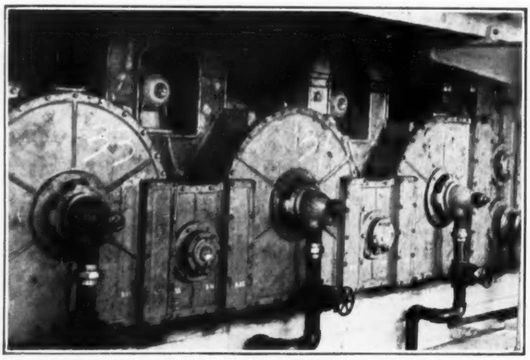


Courtesy of Minton Vacuum Dryer Corp

Fig. 2—Showing the oiling system for SKF bearings, as applied to a Minton Vacuum paper drier. Note bearing seal and stuffing box arrangement with method of oil distribution

Relative to the magnetic type of clutch,

which has of recent years come to replace the older forms of clutch design, it is well to state that it will be best to use a medium consistency grease, not only for the anti-friction bearings, but also for the quills of the clutches, for in the



Courtesy of The Pusey and Jones Corp., and SKF Industries, Inc.

Fig. 3—Showing the driving side of the dry part of a paper machine with steam joints and method of mounting. Note that gears are encased in cast iron, oil and dust tight housings, attached to the drier frames.

use of oil there will be a chance of its finding its way to the clutch faces and also to the belts to cause slippage. A further advantage pertinent to the use of grease is that the same grade as employed for other anti-friction bearings on the modern paper machine will serve the purpose.

Calender Stacks

After paper leaves the dry end of the paper machine proper, it is finished by passage between a stack of super calender rolls. This is virtually an ironing process, the paper being subjected to high pressure. Normally the higher the finish the greater will be the pressure. In the average stack there will be from seven to eleven rolls. While the size of these elements will vary, of course, in general the top and bottom rolls will be the largest, and hence their bearings will carry the greatest loads.

By reason of the heavy duty involved, wherein both pressure and speed must be considered, the bearings of the average calender stack will present a decided problem of lubrication. Concerted study has indicated that circulating flood lubrication is a practicable means of solving the problem and meeting the requirements of both heat and pressure. In older installations continuous lubrication was accomplished to a certain extent by delivering oil to the bearing of the topmost roll, the drainage from this element passing to the next below and so on down to the bottom.

By reason of the lack of adequate pressure on the oil supply, however, as well as the usual limited amount which could pass through the bearings, there was but little actual protection of lubrication. In other words, contaminating dust entering to any extent would tend to accumulate in the bearing oil grooves rather than be washed out. Development of such obstructions to any marked degree could naturally be expected to impede the flow of oil, to the serious detriment of the bearings, as experience has sometimes proved.

Pressure circulation of oil is, therefore, of distinct advantage. Study of circulating systems of lubrication has indicated that the flood of lubricant developed by leading oil under sufficient pressure and in adequate volume to each respective bearing will effectively protect them from accumulation of non-lubricating matter by washing this latter out during circulation of the oil. To insure that the oil will be of sufficient purity for continuous usage, however, proper means of filtration should be installed with such a system, to remove any foreign matter as may be carried out by the return oil and provide means for adequate rest and cooling.

This matter of cooling is of particular importance. While steam heated rolls are not used throughout the entire calender, the pressure of operation, and crowding frequently develop considerable temperature. To an extent this will be conducted to the bearings, or in low clearance elements actually generated therein. By serving them with a flood of oil, however, lubrication as well as cooling is brought about, the return oil carrying away a considerable amount of heat, which is subsequently dissipated in the filter and storage tanks, prior to re-circulation of the oil. The benefits pertinent to circulating flood lubrication can be further insured by installing ring or collar oilers on certain types of calender bearings.

Bearing design is of distinct importance as an adjunct to effective calender roll lubrication. Experience has indicated that particular attention must be given to the bottom roll, where plain bearings are involved. Here clearance is very important; obviously it must never be too great, otherwise there may be possibility of appreciable reduction of the contact area, to result in an increase in unit operating pressure. This has also been the reason for careful study of oil grooving of such bearings. As an adjunct to design, the manner of applying lubricants to these bottom roll bearings is also important. In the opinion of certain authorities, a direct lead from the oil distribution main to each of such bearings will insure the continuous delivery of cool fresh oil, and a more effective counteraction of the cumulative pressure exerted by the entire set of rolls which comprise the stack. On the other hand, the oil outlet must be of ample size to carry off the oil discharge and relieve the bearing of any possibility of back pressure or crowding.

TREATING OF RUBBER

In the manufacture of rubber products, following the process of compounding, when the raw rubber stock is treated with such products as sulfur, lime, metallic compounds, magnesia or camphor, thorough mixing is necessary. This is carried out in the mixing machines. Continued roll treatment is involved for the purpose of adequately working the stock. The rolls are of chilled stock cast hollow and fitted with connections for steam and cooling water, so that the temperature can be closely controlled, the purpose being to make the material plastic to facilitate mixing and also to cause it to adhere to one roll only while passing through the rolls. Temperature control must be close on account of the effect which it has on the properties of the material worked.

Mixing rolls are generally longer than those of the cracker, being usually from 10 inches to 28 inches in diameter and from 24 inches to 84 inches long. Due to the fact that the rolls are geared to run at different speeds, the plastic dough is thoroughly kneaded. The rubber is first thrown into the mill and when plastic the compounds are added in small amounts, the work being kept in the mill until the operator is convinced that the mixture is complete, at which time it is sliced from the roll with a lengthwise cut.

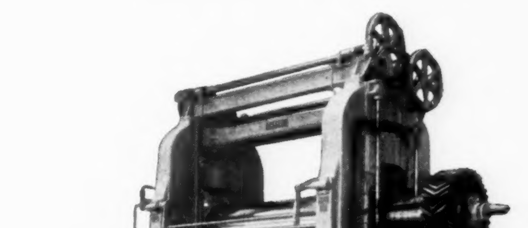
Bearings of mixers are subjected to abnormally high pressures, sometimes so intense as to lead to breaking of rolls. These pressures are caused by the action of the screw-down, coupled with such pressure as may be caused by expansion, due to heat, along with the effect of the work forcing the rolls apart. Speeds are low, however, the back roll rotating at from 100 to 150 feet per minute, the front roll at from 60 to 100 feet, but the operating temperatures are high, due to frictional and conducted heat, developed by working the rubber.

The necessity for cleanliness in the operation of rubber machinery is highly important. It is very essential to prevent petroleum contamination of fluxes, or products such as linseed oil, which may be used to soften uncured stocks, for petroleum lubricants will tend to destroy certain of the desired properties, particularly if they are allowed to come in contact with the rubber already compounded. Possibility of dust contamination from the compounds must also be considered.

For this reason, means of lubrication must be given careful consideration. This has led to study of positive means of lubrication, particular attention being given to mechanical force-feed lubricators and automatic sight feed devices, solenoid operated by electric current. Effective lubrication for mill roll journals using such means of lubrication can be accomplished with a highly refined, straight mineral oil, having a viscosity of around 750 seconds Saybolt at 100 degrees Fahr.

Many authorities, however, prefer the use of a medium bodied grease. Where grease lubrication is called for, the product can be most effectively applied with spring compression cups, feeding to the low pressure side of the box, which is usually bronze lined, properly cut with oil grooves. These latter should not be carried to the high pressure side of the bearing, for that surface should be perfectly smooth, to give a maximum of bearing surface and enable maintenance of an unbroken lubricating film. Cups designed for spring replacement in accordance with the consistency of the grease to be used, with indicators to show the grease content, are favored by some authorities for such service.

Many mill bearings have been designed with grease pockets in the boxes. In such instances some operators have used a matting of lamp wick, placing it next the journal in the slotted pockets, to enable use of a comparatively light grease. This practice may not always be conducive to positive lubrication, as some of the wicking will eventually work down into the bearing clearance, tending to clog the oil grooves. Furthermore, it may lead to the introduction of foreign matter into the bearing. When grease pockets are used, the bearing is generally provided with means for the introduction of oil as an adjunct to grease, or to facilitate starting under adverse conditions.

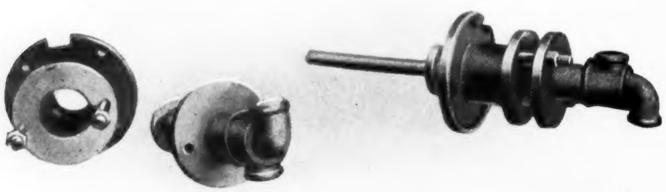


Courtesy of Farrel-Birmingham Co., Inc.

Fig. 4.—View of a four roll rubber calender. Note construction of gears and comparative size of roll bearings.

Calender Rolls

Lubrication of calender roll journals closely resembles that of the mixing mills. Here again heating and cooling connections are attached to the hollow rolls for the purpose of temperature control. High bearing temperatures may result.



Courtesy of Wm. R. Thropp and Sons Company
Fig. 5—Showing Thropp steam engine type of roll packing box, for use on rubber grinders, mixing mills and calender rolls.

Three general methods of lubricating the roll necks are available:

1. By using a comparatively heavy oil, preferably in conjunction with a mechanical pressure lubricator.
2. Delivering grease from a compression cup, or
3. The application of grease via pockets in the bearing cap.

Where there is provision for oil lubrication a highly refined straight mineral product should be used. The viscosity should range from 500 to 750 seconds Saybolt at 100 degrees Fahr., according to the prevailing temperature. As a rule, pressures are comparatively high, but speeds do not exceed 40 revolutions per minute and the temperatures do not range above 200 degrees Fahr.

Units provided with means for grease lubrication, either from cups, pockets, or slotted bearings should give little or no trouble when the correct grease is properly used. On the other hand, there is no harder test for a grease than service in a grease pocket. Trouble is bound to follow the use of an improper grease, due to the fact that the heat may cause the oil to separate from the soap.

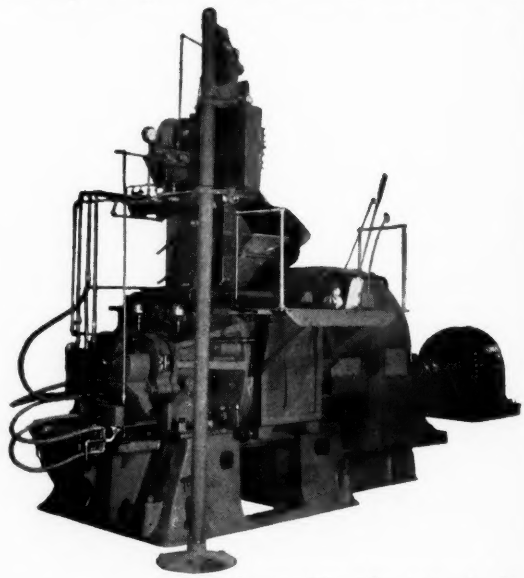
This should always be guarded against, as improper lubrication will exert a direct influence upon the uniformity of the work. Since it may cause wear on the bearings, its importance can be readily appreciated.

TEXTILE FINISHING MACHINERY

In the lubrication of textile finishing machinery the problem is distinctly a dual one of machine lubrication and cloth protection. For this reason the most careful judgment in selecting and applying lubricants should be exercised.

In the case of scouring and fulling machinery, the possibility of soapy water, etc., penetrating to the roll bearings and perhaps washing out the lubricant must be guarded against. Lubrication can normally be best effected if the bearings are properly constructed and adequately protected. On the other hand, this is not always the case. We must remember, too, that either oil or grease can be used, according to the provisions for lubrication. Grease would perhaps best meet the exacting conditions of uneven pressure and possible washing, coupled in some cases with high temperature. For this purpose a product composed of a nonsoluble soap will usually be most satisfactory. Its consistency should be that of a medium compression cup grease. On the other hand, where ball or roller bearings are installed, a more fluid product would be better, similar to a medium liquid grease.

Where oil lubrication is required for plain bearings, a 300 to 500 viscosity straight mineral product will probably meet conditions satisfactorily. In the case of ball and roller bearings either grease or oil can be used, according to bearing design and operating temperatures.



Courtesy of Farrel-Birmingham Co., Inc.
Fig. 6—View of a Banbury Mixer, as designed for the rubber industry. Note that grease cups are used for the journals of the mixing rotors.

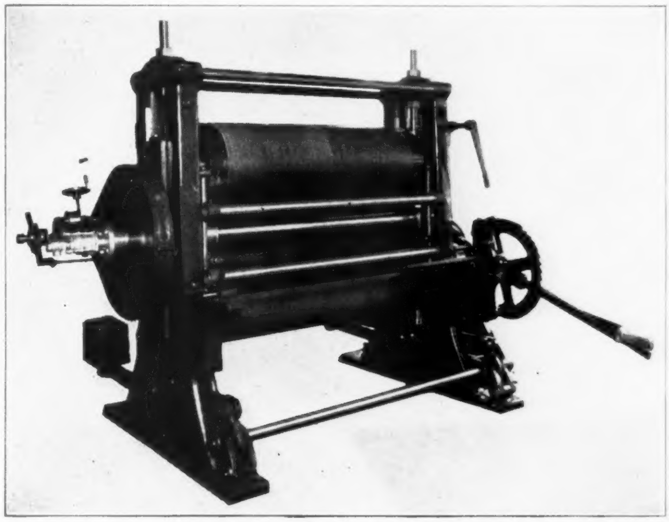
Here it is quite as much a problem of protecting the balls, rollers and raceways from corrosion as of reducing friction.

The wearing parts of other machinery employed in raising, napping, cropping, singeing

and pressing, etc., can usually be effectively lubricated by oils or greases of similar characteristics as above, according to the nature of their construction, the means involved for lubrication and the temperatures employed.

The finishing room will usually be subject to somewhat higher temperatures than elsewhere in the mill, due to the use of steam and gas for heating purposes. We must, therefore, take this factor into consideration, as well as the possibility of damage to the goods. Use of too light a lubricant on the tentering frame or ironing and pressing machine roll bearings, for example, might not only lead to abnormal wear, due to lack of body in the lubricant, but also to a certain amount of sprayed or leaked oil contaminating the goods with oil spots.

Calender roll bearings will require the same careful thought emphasized in the previous discussion of calender bearing lubrication in the paper industry. On the textile calender, however, grease has been found to be most adaptable, provided a product of sufficiently high melting point is used, which will retain adequate consistency when subjected to the prevailing temperatures.

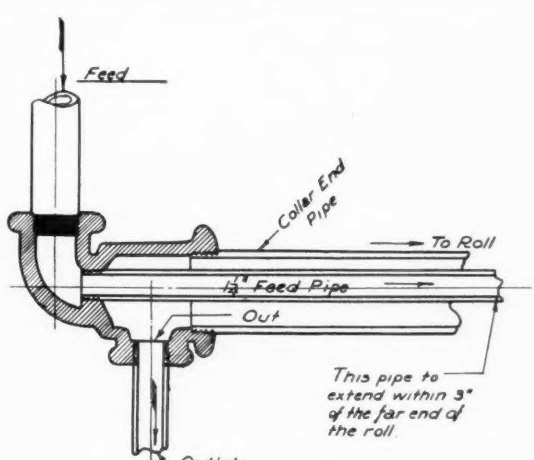


Courtesy of H. W. Butterworth and Sons Company

Fig. 8—Entering side of a Butterworth silk calender, showing stuffing box for steam heating connection.

Worm Reduction Gear Lubrication

Worm reduction gears, in company with other types of speed reducers are particularly useful wherever it is desirable or necessary to



Courtesy of Wm. R. Thropp and Sons Company

Fig. 7--Arrangement of piping and stuffing box for application to rubber mill machinery. Note points of entry and outlet of steam and water.

eliminate power losses through excessive lost motion. As a result, they are used to supplant such methods of power transmission as friction wheels, and belt or rope drives where direct connection is practicable.

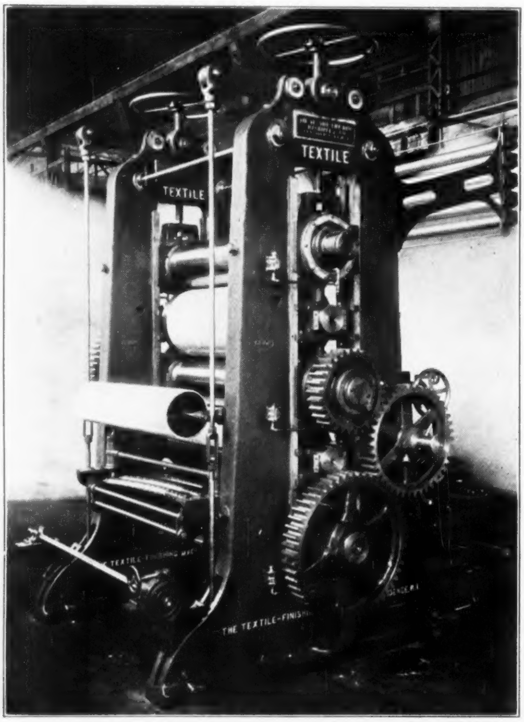
Between the average worm and gear, contact is a combination of sliding and rolling action. The percentage of sliding motion varies with the ratio and helix angle. Rolling action is highest on installations of low ratio where the helix angle may be as high as 45 degrees.

It is important to remember that tooth friction will depend to a considerable extent upon the suitability of the materials used, the alignment of the gears, the accuracy of their cutting and the freedom with which their teeth engage or mesh, as well as the condition of the bearings. Under ideal conditions, the teeth should roll so smoothly into each other and with such a constant relation in velocity between their respective surfaces that this friction will be reduced to a minimum. In this connection, the lubricant if it is properly prepared and carefully applied will play an important part in the reduction of noise, prevention of wear and elimination of vibration or chattering between the teeth.

Worm reduction gears are applicable where motion is to be transmitted between two non-intersecting shafts, located at right angles to each other and not in the same plane. In construction such an installation involves a worm gear which is a cylinder, on the surface of which is cut one or more continuous helical

teeth, which more or less extend round and round over the entire length. The worm is usually the driving element. Its companion mechanism is a helical type of gear.

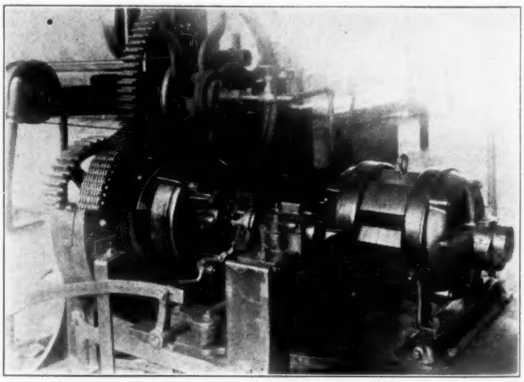
Devices of this nature are especially suited to conditions requiring a comparatively high reduction ratio with a minimum of gears. Properly constructed a worm reduction gear is claimed to give exceptionally silent operation and high efficiency. It is compact, can be readily equipped with an oil-tight housing, and can be installed in locations which might often prohibit other types of drives. Lubrication can be accomplished by running the worm or gear in an oil bath or by circulating the oil during operation, by a specially designed system.



Courtesy of The Textile-Finishing Machinery Co.
Fig. 9—Showing a 5-roll Universal Textile Calender. The top, middle and bottom rolls are equipped with roller bearings, being oil lubricated as shown.

Operating and constructional conditions, however, will require a relatively wide variation in the viscosity of a lubricant. In certain instances, for example, a gear lubricant of approximately the viscosity of a mineral steam cylinder oil will be required. In others a machine oil of from 300 to 750 seconds Saybolt viscosity at 100 degrees Fahr., will suffice, further, in abnormally low temperature locations, even spindle oils have indicated their suitability. Essentially the problems are to maintain the requisite film of lubricant on the gear and worm teeth; to reduce the starting and operating torque as far as possible and to lubricate the shaft bearings with a minimum of frictional resistance. Ball and roller bearings are extensively used in such installations, especially for the worm shaft, and for the purpose of taking up end-thrust. In theory, anti-friction bearings should be served with as low a viscosity lubricant as possible, for essentially the function of this latter is to protect the highly polished surfaces rather than to lubricate. So a compromise may often be necessary, especially when the one lubricant must be used throughout the gear set and protection of the bearings is as important as protection of the gears.

Where worm gears are bath lubricated the level of the oil is of decided importance, for the development of "drag" or excessive internal friction may become a decided factor in the matter of power consumption. So as a rule the oil should be carried at such a height as to insure suitable dipping of the teeth of the lower element; submergence of too much of either the gear or worm is not advisable. Usually provision will be made for distribution of the lubricant by the teeth of the gear to the respective shaft and thrust bearings, or else these will be provided for external or independent lubrication. Where the worm is located below the wheel or gear, the oil lever should usually be carried at the center line of the worm shaft. Where the worm is above the gear, however, the problem may be more difficult, for the gear teeth will carry less lubricant to the worm than this latter would to the gear teeth. So a heavier, more adhesive lubricant may often be necessary, or the level of the lubricant may have to be raised considerably higher than for normal spur gear requirements.



Courtesy of Link-Belt Company
Fig. 10—Silent chain drive, operating a bleachery calender machine. Note heat control piping connections.

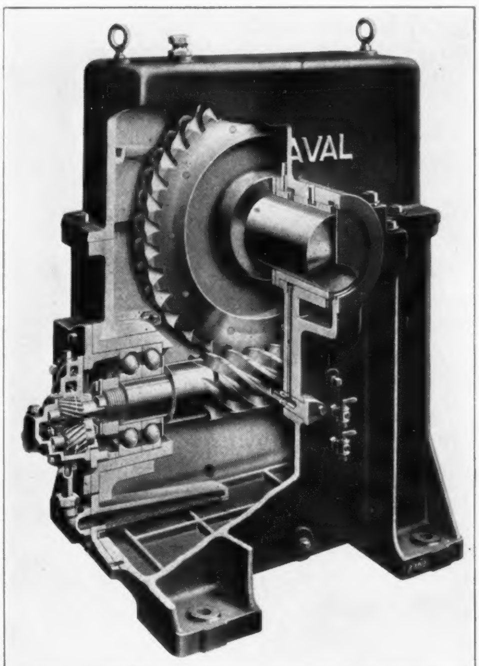
Whatever the viscosity of the lubricant, low pour test and "oiliness" or the ability to adhere and lubricate with a minimum of fluid

friction are the essential requirements. Pour test, as an indication of fluidity at low temperatures should be as low as possible, otherwise under colder operating conditions congealment may occur, especially when the gear set is idle, with the result that high power consumption may result, with the possibility of insufficient lubrication at the start.

SELECTION OF WORM GEAR LUBRICANTS

With an insight into the lubricating requirements of a typical worm reduction gear, selection of suitable lubricants can be studied. There are certain definite properties which such products should in general possess if they are to function effectively, i.e.:

1. Sufficient lubricating ability or "oiliness" to insure the reduction of both solid and fluid friction to a minimum.
2. Viscosity or body commensurate with the method of lubrication and the amount of heat that may be encountered, such that a suitable film will be insured between the teeth as they become enmeshed, and the effects of both pressure and temperature

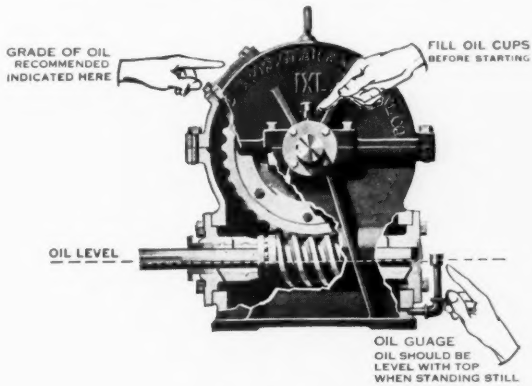


Courtesy of DeLaval Steam Turbine Company

Fig. 11—Cut-away view of a DeLaval worm reduction gear, showing details of the pressure oiling system. The worm threads and teeth of the worm wheel are lubricated by a spray of oil, circulated by a pump through passages in the casing to suitable spray nozzles.

resisted. Pressure, of course, exerts a squeezing out action; temperature renders a lubricant more or less fluid, according to its degree, for viscosity is reduced as temperature rises.

3. A sufficient degree of adhesiveness so that in event of use under exposed or semi-enclosed conditions a requisite film will remain on the teeth to resist the tendency of centrifugal force to throw it off.



Courtesy of Foote Brothers Gear and Machine Co.

Fig. 12—Details of an IXL worm gear speed reducer lubricating system, wherein the bearings and gear teeth are lubricated by splash through the action of the worm gear.

4. As little tendency as possible to congeal, harden, crack or become brittle when used under lower temperature conditions; or, to carbonize and chip if exposed to abnormally high temperatures.

To reduce wear, noise, misalignment of parts, rusting, stripped teeth, vibration, etc., it is absolutely essential that the above requirements be given consideration. It is also important to study them from the viewpoint of their relative importance, depending, of course, on the design, mode of operation, whether or not automatic or bath lubrication is practicable, and the nature of the installation.

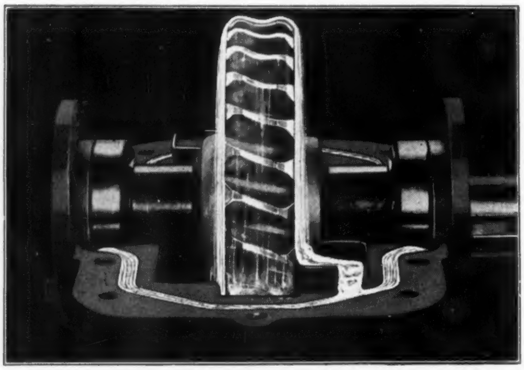
Pressure is of distinct importance in the study of worm gear lubrication. As a rule tooth pressures will be high and the bearing surfaces, due to their relatively small areas of contact, will carry heavy loads.

Inasmuch as contact between the worm and gear is not as perfect at the start as it becomes after the worm has seated itself in the gear, the unit pressure between any two such elements will normally be greatest at the start, decreasing as the wearing-in process advances. it becomes minimum and constant after seating is completed. It is important to remember that it will require some time for the wearing-in process of a worm and gear to become complete, depending upon the ratio and imposed load.

Wear may be evidenced by abnormal back-lash. In a worm gear driving in one direction, however, due to the fact that there are several teeth in contact back-lash will normally not be noticeable.

Should wear occur in a worm gear due to

breaking down of the oil film and impaired lubrication, it has been found that particles of bronze are worn from the gear and adhere to the worm, in the zone of contact, presenting a comparatively rough surface which will tend



Courtesy of The Cleveland Worm and Gear Co.
Fig. 13—Showing the lubrication of a Cleveland speed reducer unit, with upper half of the housing removed to show oil scrapers and grooves. Oil is carried around by the gear, being scraped off by the scrapers at front and back, from which it flows through oil grooves to the bearings.

to score the gear and cause continuation of wear. If this can be caught in time further wear can be prevented by removing the worm and cleaning all traces of bronze from the worm threads. For relubrication a grade of lubricant should be used which will afford the necessary protection, commensurate with the operating temperatures and loads.

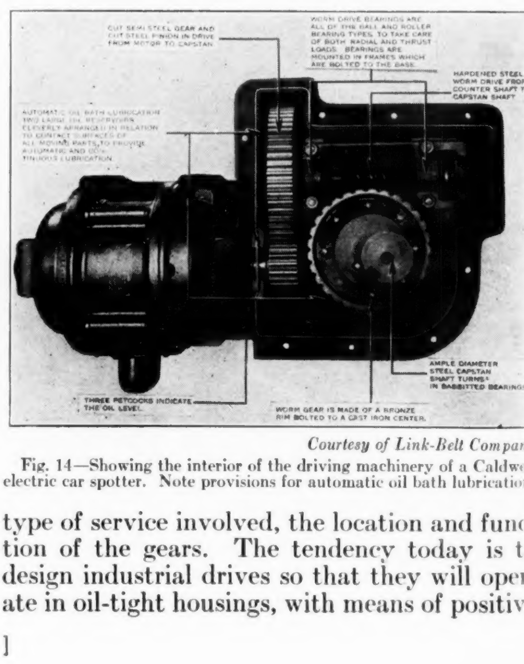
For this reason, considerable attention has been devoted to the study of gear lubrication by authorities in the oil industry. According to the service conditions a wide variety of lubricants are available today, varying in consistency or body from light fluid oils, through the cylinder stock range, to the grease or soap thickened type of lubricant. The ultimate object is, practically always, to meet viscosity requirements. Non-lubricating fillers will make this possible, but they oftentimes reduce the ultimate lubricating ability and film strength of the product to a marked extent. In addition, lubricants containing fillers will lack, to an appreciable degree, the adhesive characteristics which may so often be necessary. As a result, when they are used under exposed conditions, on high speed gears, subjected perhaps to the possible detrimental effect of water, acids, or alkalies, the worm and gear teeth may suffer materially, due to the inability of such lubricants to resist the action of centrifugal force, corrosion, or the washing action of water.

The use of straight mineral products or mineral oils slightly compounded with high grade fatty oils should therefore be advocated wherever possible. As a general rule, the viscosity of a worm gear lubricant should be relatively high, varying from 100 to 200 seconds Saybolt at 210 degrees Fahr. Certain conditions of operation will, of course, require special consideration, according to temperature. Under cold conditions the viscosity should be proportionately lower, as already stated.

Grease should be used as a worm gear lubricant only under certain conditions, due to its lack of adhesiveness and the tendency to squeeze out from between the teeth, leaving an imperfect lubricating film. It must be remembered that from a lubricating point of view greases are only as good as the mineral oil which they contain. Their soap content is merely a carrier, to give the requisite body or consistency to the resultant product. Soap does not lubricate to any material extent, though it may serve as a cushion provided tooth pressures are not too high. Greases are applicable as gear lubricants wherever their characteristics will meet the pressure and temperature conditions prevalent. In cold weather they are suited to automotive service where relatively light-bodied products and the use of a low pour test oil may be required. Here the gears run in a bath of the lubricant which will generally be of a semi-fluid nature. Greases are also advantageous on smaller gears, such as are so frequently employed as individual drives for industrial machinery, under operating conditions where leakage and staining of the product may be a factor. As a rule a properly prepared grease can be more readily washed off of fabrics than a straight mineral gear oil.

METHODS OF LUBRICATION

Application of worm gear lubricants will depend upon the design of the housing, the

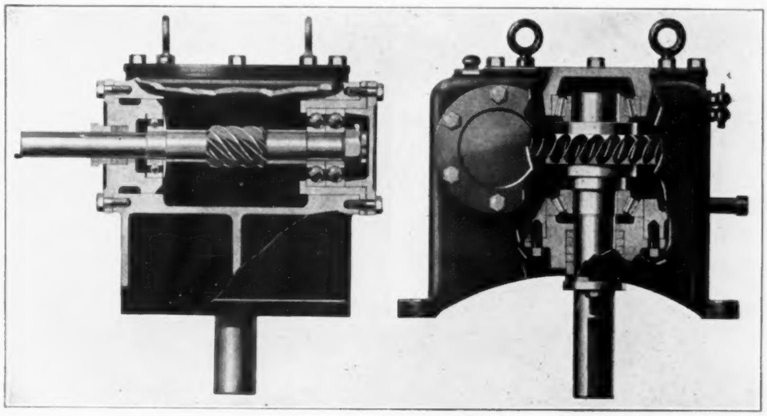


Courtesy of Link-Belt Company
Fig. 14—Showing the interior of the driving machinery of a Caldwell electric car spotter. Note provisions for automatic oil bath lubrication.

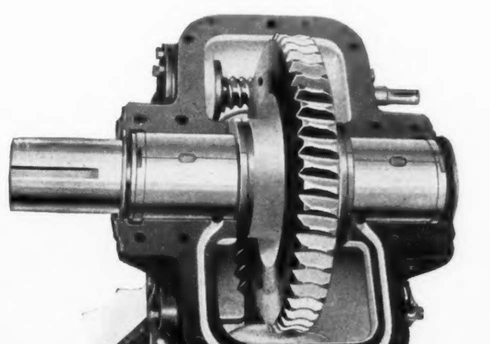
type of service involved, the location and function of the gears. The tendency today is to design industrial drives so that they will operate in oil-tight housings, with means of positive

and continuous circulation of the lubricant to gear teeth and bearings. In certain types of service, on the other hand, bath lubrication is perfectly practicable, particularly where a sufficiently heavy lubricant is used to follow the worm or gear teeth during rotation and maintain a suitable film thereon at all times.

The actual selection of the lubricant should only be made after study of the provisions for application, and in accordance with the temperature and other operating conditions involved. Many installations will require special consideration, based upon the manufacturers, recommendations as to the size and arrangement of the speed reducing elements, their location in the housing with respect to each other, the provisions for automatic distribution of lubrication, and the nature of the products being handled. Where these latter are fragile, or perishable, as would be textile goods, paper, bread or flour, their protection may relegate the attainment of effective lubrication to a subsidiary position, should the speed reducing elements have any tendency to leak. Elsewhere as in the steel mill, the protection of gears is paramount, for any occurrence of abnormal wear on the teeth may often affect the other wearing elements materially.



Courtesy of The Cleveland Worm and Gear Company
Fig. 16—Showing a Cleveland vertical worm reduction gear unit. This is lubricated entirely by splash, oil being carried to the proper level to reach the upper gear shaft bearing.



Courtesy of DeLaval Steam Turbine Company
Fig. 15—Top view of a DeLaval double reduction worm gear, with cover removed, showing type of design of both worm and worm wheels.

Where an oil-tight casing or housing is employed, the gears may be capable of lubrication apart from their shaft bearings. This is probably the most ideal condition, for it makes possible the use of a lubricant of just the right viscosity to withstand such pressures and temperatures as may be involved. As a rule, bath, pressure or splash lubrication will be applicable. Where the former is employed a somewhat heavier product will be necessary than where the lubricant is forced or splashed onto the the teeth under a certain amount of pressure.

In many speed reducers, however, the gears will be so designed that the same lubricant must serve both gears and bearings. Here the lubricant must be sufficiently fluid to follow the bearing clearances and yet viscous and adhesive enough to maintain a satisfactory film on the gear teeth.

The use of anti-friction bearings frequently presents another point for consideration, wherever they are contained within the case, for their protection is as important as the lubrication of the gear teeth, and the reduction of starting and running torques as far as possible.

All worm gears are not encased, however. Frequently they may be almost entirely exposed, as are the gears on certain hoisting and excavating machinery, or the drives of some types of sugar machines. Here the lubricant must usually be applied by hand. So a highly viscous product will be necessary. As a rule a viscosity of from 600 to 1000 seconds Saybolt at 210 degrees Fahr., will best resist the effects of weather, centrifugal force, and dusty or dirty conditions wherever these may be involved. Such a lubricant will remain the longest on the teeth, requiring but relatively infrequent renewals, provided it is properly distributed by application at the point of mesh.

Where exposed gears operate with the worm

located below the gear and partially enclosed in an oil-tight pan to permit of bath lubrication, relatively automatic lubrication may be practicable, though, of course, it will be necessary to keep the level of the lubricant as low as possible, to prevent splashing or throwing, especially if the gear runs at fairly high speed. Usually good practice dictates that the lubricant should be maintained at the level of the center line of the worm. The lubricant, however, must be of the requisite viscosity and possess sufficient tenacity to adhere to the worm teeth and be carried and equally distributed to the teeth of the gear.

Under slower speed conditions a lubricant of about 200 seconds Saybolt viscosity at 210 degrees Fahr., will meet these requirements. Where speeds are higher, however, or temperatures excessive, it may be advisable to use a proportionately heavier product.

In the case of entirely exposed gearing, dirt and other foreign matter may preclude effective lubrication, however carefully the problem be analyzed. Gears on certain types of clay-working machinery are a good example of such a condition. Here the best one can do is to seek a lubricant which will stick, and yet not be so viscous as to ball up when contaminated with dust or dirt.

COLD ROOM OPERATIONS

Improved methods of handling such products as ice cream have led to an interesting use for the worm reduction gear in connection with conveyor elements. In a modern cold storage room of an up-to-date ice cream plant the ice cream, after it has left the chilling process, is put into storage in a cold room, ranging in temperature from –35 to –60 degrees Fahr. In this room the containers are handled by means of conveyors, driven by worm reduction gearing, located directly adjacent to the conveyor elements in the cold room, or outside the room with connections to the conveyor through an extension shaft. Where the reduction gears are located in the cold room and exposed to the prevailing temperatures, it is obvious that the most careful study must be given to the choice of the lubricant, so that it not only will enable easy starting, but also afford adequate protection to worm and gear teeth as well as the shaft bearings during operation.

A product of suitable fluidity even at the lowest temperature of the room is required, which will in addition retain sufficient of its adhesiveness and lubricating ability to withstand a possible temperature rise in the gear case of from sixty to eighty degrees during more or less continuous operation.

Recent study of a variety of lubricants suggested for this purpose has indicated that products of a specially refined crude, with a pour test of –25 degrees Fahr., or better, will best meet these requirements. Actual observation of an experimental gear, subjected to cold room temperatures, has indicated that a sufficient film of lubricant can be formed almost immediately upon the gear teeth, even after as long as 48 hours shutdown.

It is of further interest to note that with such a lubricant it has been possible to bring the gear itself up to speed within from two to four seconds. Under full load operation, however, this time might be lengthened to a certain extent

The value of adding compound to such a lubricant is as yet debatable. Further developments may indicate that the use of a certain amount of compound may be as beneficial to a worm gear lubricant operating under cold conditions as to a cylinder oil used for the lubrication of similar gears under normal operating temperatures.

It is important to remember, however, that there may be possiblity of oxidation under sub-normal temperatures, particularly when the range of fluctuation may be wide. This might lead to the formation of free fatty acids, which, in some cases, might attack the metallic surfaces of the anti-friction bearings, which are so extensively used today in such gears.

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